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MODELING AND SIMULATION FOR EVALUATING THE C3 STRUCTURE IN A NCW MISSION ENVIRONMENT

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ABSTRACT

This paper proposes a simulation model for evaluating the command, control and communication (C3) structure in a network centric warfare mission environment. When a mission is executed, much interaction between commanders and combatants occur through a predefined C3 structure. Our model focuses on measuring the mission completion time, which is dependent on the C3 structure. To achieve this goal, we model the flow of information and command messages between the mission participants, and identify the time-related factors. It is especially important to model a time delay that can be divided into the delay due to the limits of human capabilities and due to communication delay. For measuring the delay of the former type, we design the commander as an infinitely buffered single server with workload-dependent processing time. For communication delay, we use a propagation loss model. Finally, simulations are performed to evaluate the performance of the various C3 structures.

1 INTRODUCTION

Network centric warfare (NCW) is a modern concept of warfare, which facilitates information sharing, expanding shared situational awareness, and improving the combat effectiveness. While shared information is turned into improved results of combat, much interaction between the commanders and combatants occurs through a predefined C3 structure. The structure consists of a command and control (C2) structure and a communication structure. Messages are transmitted from the combatant to the commander through the communication structure. The commander makes the decision by using the shared information, and sends the command message to the combatants through the C2 structure. Thus, observation-orientation-decision-action cycle time is dependent on how the C3 structure is created. In general, it is not a simple problem to determine which C3 structures are optimal because these structures have different advantages and disadvantages.

This paper proposes an evaluation model and a simulation technique to determine which C3 structure is suitable for an NCW mission environment. The mission consists of a number of tasks that entail the use of resources such as combatants, and are carried out by an individual commander or a group of commanders. Although there have been previous studies on evaluating C3 structures and finding the optimal structure (Kang and Kim 2013, Park et al. 2012, and Liu et al. 2011), we extend the study by focusing on measuring the mission completion time while utilizing some of the advantages of the previous studies.

2 MODELING FOR EVALUATING THE C3 STRUCTURE

We select the mission completion time as a key metric to evaluate the C3 structure. To determine the metric, we first represent the flow of information and command messages between the mission participants. The information message from each combat entity is periodically generated, and is then shared through the communication structure. This cycle of information generation is different for an idle and active combat entity. The command message is not generated periodically, but is generated by a rule-based algorithm; once a commander identifies a course of action, the commander sends the command message for assigning the task to the appropriate resources. Then the combat entities to be assigned to the task prepare for the task execution by doing some action, such as moving toward the task location, and then report their readiness to the commander. The commander confirms the readiness of the resources and sends the command message for the task execution. The resource then executes the task and reports the result.

For measuring the mission completion time, it is especially important to model a time delay. This delay can be divided into time delay due to the limits of human capabilities and communication delay. To measure the time delay with the human dimension, we design the commander as an infinitely buffered single server with workload-dependent processing time. Each information and command message has a certain amount of workload, and its processing time depends on the total amount of the workload in the server and buffer as well as the server's workload capacity according to Yerkes-Dodson inverted-U relationship. In addition, the commander has an additional workload when coordination is in progress between a group of commanders assigned to the same task, and when task-resource reassignment is required because of resource loss during task execution. The communication delay can be measured by the propagation loss model proposed in Shin et al. (2013).

3 SIMULATION

To evaluate the C3 structure, we construct an agent-based simulation which implements the proposed model discussed in section 2. The input data of this simulation are classified into three categories— mission participants, task, and mission. The input data related to the mission participants include the number of commanders and resources, the workload capacity of the commander, the period to update information by resources, etc. The input data related to the task consists of the result of task-resource assignment, precedence between the tasks, location where the task is performed, etc. The input data about a mission include the battlefield terrain and the degree of resource loss after task execution, which is related to the communication delay and task difficulty, respectively. The output of this simulation is the mission completion time.

Preliminary simulations are conducted for four simple C3 structures. We consider hierarchical and parallel C2 structure, and apply point-to-point and blackboard communication architectures to each C2 structure. Further, we perform a sensitivity analysis by varying the input data of the simulation.

4 CONCLUSION

We propose modeling and simulation to evaluate the C3 structure from the perspective of mission completion time. It is expected that our proposed model can be used to evaluate the C3 structure suitable to the general characteristics of missions.

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